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AUTHOR Troutman, James G.
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ABSTRACT

Investigated were the effects of using intelligence quotients, high school rank, College Entrance Board Scholastic Aptitude Test scores in mathematics, and high school mathematics grades as predictors of success in finite mathematics. One hundred twenty-three students were included in the study. The SAT-Mathematics score was the best predictor followed by the high school rank and the high school mathematics grade average. The variable of least value was the intelligence quotient. The full model had a correlation coefficient of .611. Recommendations for use of the results of the study are included. (Author/RH)

Predictors of Success in Freshman Mathematics

Applied Educational
Research and Evaluation

by

James G. Troutman, M. A.

York College of Pennsylvania

DR. KENNETH MILLER

EASTERN PENNSYLVANIA

A PRACTICUM PRESENTED TO NOVA UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF EDUCATION

NOVA UNIVERSITY

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James G. Troutman

May, 1977

APPLIED EDUCATIONAL RESEARCH
AND EVALUATION EASTERN PENNSYLVANIA

York College of Pennsylvania has an "open door" admissions policy. As a result of this policy mathematics courses are geared to several levels. The majority of students are enrolled in finite mathematics but a Calculus sequence and a basic mathematics sequence is offered. The purpose of this practicum was to examine the effects of using intelligence quotients, high school rank, College Entrance Examination Board Scholastic Aptitude Test scores in mathematics and high school mathematics grades as predictors of success in finite mathematics.

The 627 students enrolled in finite mathematics during the fall 1976 semester were screened by computer to select only those with the necessary information on file. This produced a group of 123 students on which to basis the study. A step-wise multiple linear regression was

conducted to test the predictive value of each of the independent variables. In particular, the analysis was designed to test if there was a significant positive correlation between the grade received in finite mathematics and any combination of the independent variables.

The findings of this research indicated that all combinations of the independent variables were significant at the .01 level. The SAT-Mathematics score was the best predictor followed by the high school rank and the high school mathematics grade average. The variable of least value was the intelligence quotient. The full model had a correlation coefficient of .611. This indicates that about thirty-seven percent of the variation of the grade in finite mathematics was explained by this set of four independent variables.

The recommendations that were made as a result of this research included 1) that the placement of freshmen in mathematics courses be determined by SAT-Mathematics scores, high school rank, high school mathematics grades and intelligence quotients, in that order 2) that other departments study predictors of success in their freshman courses 3) that other factors be studied as possible predictors of success in freshman mathematics.

TABLE OF CONTENTS

	Page
PRACTICUM EVALUATION FORM	ii
INTRODUCTION	1
Statement of the Problem	1
Significance to York College	1
Method of Investigation	2
BACKGROUND AND SIGNIFICANCE	3
Review of the Literature	4
Summary of the Literature	6
PROCEDURES	6
Definition of Terms	6
Limitations of the Study	7
Basic Assumptions	8
Procedures for Collecting the Data	8
Procedures for Treating the Data	9
RESULTS	10
DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS	15
Discussion and Implications	15
Recommendations	19
BIBLIOGRAPHY	21
APPENDIXES	
Peer Reader Form	24
Practicum Proposal Approval	25
Practicum Evaluation	26

LIST OF TABLES

Table		Page
1.	Means and Standard Deviations of the Variables	10
2.	Correlations Between the Variables	11
3.	Crossbreak S151 Grades verses I.Q.	11
4.	Crossbreak S151 Grades verses HSR	12
5.	Crossbreak S151 Grades verses SAT-M	12
6.	Crossbreak S151 Grades verses HSMG	13
7.	Correlations and Equations For the Step-wise Linear Regression	14
8.	Predicted Mean S151 Grade	18

INTRODUCTION

Statement of the Problem

This paper examined the use of intelligence quotients, high school rank, College Entrance Examination Board Scholastic Aptitude Test in Mathematics and high school mathematics grades as variables to predict success in freshman mathematics as York College of Pennsylvania. The basic question to be attacked was does one of the above variables or any combination of these variables provide an accurate prediction of the probability of a student being successful in freshman mathematics.

Significance to York College

York College has a liberal admission policy. As a result of this policy mathematics courses are geared to several levels. The Calculus is offered for students who enter with the traditional college preparatory background. Finite mathematics and college algebra is offered to those students who had business, vocational or other non-college preparatory backgrounds. A review of arithmetic and basic algebra is offered for those students who have a weak background in mathematics.

During the fall semester 1976, there were sixty-seven students who opted to take the Calculus. There were 627 students placed in basic mathematics and thirty-nine

were placed in basic mathematics. From these numbers it is easy to see that the majority of students take finite mathematics as their freshman mathematics course. This is a result of direct placement by the admissions office of the College.

Of the 627 students enrolled in finite mathematics, seven withdrew and ninety received a failing grade. Although some of this is to be expected due to the liberal admisssion policy, it can be minimized if the students who are likely to fail are identified and placed in the basic mathematics course. The positive psychological experience and self-confidence developed in the basic mathematics course can then be transfered to the finite mathematics.

The staff of the Admissions Office of the College has done a fine job in placing freshman in the appropriate courses. This research should be of assistance in improving their procedures. By proper placement the student withdrawal and failure rates should be minimized thus allowing for a lower attrition rate due to academic probation and suspension.

Method of Investigation

A step-wise linear regression was conducted to test if any of the variables (intelligence quotient, Scholastic Aptitude Test in Mathematics, high school rank, or high school mathematics grades) or any combination of these variables was an accurate predictor of the grade

received in finite mathematics. In particular, the analysis was designed to test if there was a significant positive correlation between any one of the variables or any combination of the variables and the grade received in finite mathematics. A one-tailed r test was conducted at the 0.01 significance level. For details of the procedures the reader is directed to the Procedures and the Results sections of this paper.

BACKGROUND AND SIGNIFICANCE

Because of the use of three different mathematics options for freshman the placement of students in the appropriate course is difficult. The Calculus although required in some curricula is basically chosen by students who want to take it rather than being required to do so by their major department. If a students admission file is very weak in the area of mathematics the student is then required to take basic mathematics. In all other instances the student is scheduled finite mathematics.

In most cases the admission question of what mathematics course to take is a simple one to answer. Two basic problems arise. First, the student is well qualified to take the Calculus but it is not required by his major or it is not recommended as an option by the admissions office. Many times this student is bored in the finite class. The second problem occurs when it is not clear if the student will be able to succeed in finite mathematics

yet the basic mathematics course is well below his ability or he has no desire to take that course. It is hoped that this research will be able to better predict the chance that a student will be successful in finite mathematics.

Review of the Literature

In a review of 263 college admission studies conducted over a ten-year period, Fishman and Pasanella (1960) reported that there was a mean correlation of 0.50 between "high school grades" and grades obtained in the first year of college. They also found a correlation of 0.47 between "test" scores and grades obtained in the first year of college.

Chester Judy (1975) studied both high school records and admission testing. While discussing high school records he writes:

> Hundreds of studies have shown that prediction of college achievement based upon weighted combinations of test results and information from high school records (such as high school rank) are more accurate than predictions made from test scores alone, or from high school records alone. These studies have also generallly shown that optimum prediction is obtained when more consideration, or weight, is given to high school record information than to test information.

Judy (1975) points out in that same article that in practice the research is not followed:

> A fourth and final observation is that, historically for the purpose of academic prediction, much more attention has been given to the measurement of intelligence, mental ability and scholastic aptitude than to the qualification of any equivalent amount of data obtained from the existing academic record, data extending over a longer sample of an individual's functioning than two or three hours of test behavior.

In general Judy is saying that the research has shown that the high school record is the best single predictor of college achievement, and that the most valid prediction occurs when high school record information is given more weight than selection-test scores in combined prediction. In actual admissions practice, however, test scores are often given the most weight.

Kenneth M. Wilson (1973) conducted a study at Vassar College. Performance on the Scholastic Aptitude Test-Verbal and Mathematical, the high school class rank, and the general level of measured secondary school achievement (indicated by the average CEEB Achievement Test) were used at Vassar as both admissions measures and as predictors of freshman year performance. It was found that the single best predictor was either the CEEB average or the high school rank. The SAT-V was the third best and the SAT-M provided information of the least value. However, the combination of scores provided a better indication of probable performance than any single score.

In a study of almost three-hundred articles of research related to predictors of college success, Pedrini and Pedrini (1974) found the following:

> The research concerned with the prediction of college achievement has considered many single and multiple predictor variables. The literature is replete with reports studying the predictive validity of high school grades and achievement/aptitude test scores. While many factors are important, it appears that for the majority of students, the high school average (or class rank) is the best single predictor of college grades.

Concerning attrition the same authors find:

> The majority of data has suggested that students who persist, transfer, drop out, or flunk out can be discriminated on the basis of high school grades (or rank) and/or standardized test.

In an attrition study conducted at a large urban university with 1125 students Bean and Covert (1973) concluded that academic aptitude measures (SAT-V, SAT-M) discriminated between persisters and academic dismissals.

Summary of the Literature

The literature consistently points to two areas of concern when dealing with both predictors of success and persistence. The first area is achievement/aptitude tests. The second is the high school record. Although at times the literature is contradictory in what is the best single predictor it is consistent in that the use of multiple predictors seems to be most effective. Where one variable is singled out the best predictor then appears to be the high school grade average or class rank.

PROCEDURES

Definition of Terms

1) High School Mathematics Grades (HSMG) - the grade point average for all mathematics courses taken in high school. A grade of 4 indicates an A, while tthe grade of 0 indicates an F. This is one of the independent (X_5) variables.

2) High school rank (HSR) - the ranking of the student in his or her graduating class by quintiles. One will indicate the top fifth and five the bottom fifth. This is one of the independent (X_3) variables.

3) Intelligence quotient (IQ) - measured by the Stanford-Binet intelligence scale. When different test were used they were equated to the Stanford-Binet scale using the appropriate mean and standard deviation. This is one of the independent (X_2) variables.

4) Intervening variables - health, marital status, socio-economic status, extra-curricular involvement and social adjustment.

5) Scholastic aptitude test in mathematics (SAT-M)- the test administered several times annually by the College Entrance Examination Board.. This is one of the independent (X_4) variables.

6) S151 grade (S151) - the grade earned by the student in S151 Finite Mathematics. This is the dependent (X_1) variable.

Limitations of the Study

1) The extent to which York College mathematics courses compare to those at other colleges limits the external validity of the investigation.

2) Any of the intervening variables may limit the accuracy of the study.

3) The extent to which the independent variables accurately predict the dependent variable limits the

accuracy of this study.

Basic Assumptions

1) It is assumed that the possible intervening variables will not adversly affect the results of this study.

2) It is assumed that the limitations will not adversly affect the results of this study.

3) It is assumed that the prediction of the dependent variable from the independent variables will be a linear model.

4) It is assumed that academic achievement and attrition are directly affected by the grade received in finite mathematics.

Procedures for Collecting the Data

The 627 students enrolled in finite mathematics during the fall 1976 semester will be screened by computer to select only those students with the following characteristics:

1) first semester freshman,

2) have intelligence quotients on file,

3) have high school ranks on file, and

4) have scholastic aptitude test scores in mathematics on file.

All the students thus selected had their high school mathematics grade averages calculated from the data in their admissions file.

Note - All information required for this study was obtained from records found in the computer center, records office, admissions office and mathematics office of York College of Pennsylvania.

<u>Procedures for Treating the Data</u>

1) The mean and standard deviation were computed for the dependent variable and each of the independent variables.

2) Pearson-Product-Moment correlation coefficients among the independent variables were calculated.

3) Pearson-Product-Moment correlation coefficients between the dependent variable and each of the independent variables was calculated.

4) A crossbreak between the dependent variable and each of the independent variables was tabulated.

5) A step-wise multiple linear regression analysis was made between the dependent variable and the four independent variables.

The following null hypothesis was tested: there is no positive correlation between the dependent variable and any combination of the independent variables.

Level of Significance	$\alpha = 0.01$
Critical r Value (one-tailed test)	0.21
Null Hypothesis	H_o: $r < 0.21$
Alternate Hypothesis	H_a: $r \geq 0.21$

Degrees of Freedom 122

One-tailed Test 0.95 Percentile value

H_o will be rejected and H_a accepted if $r \geq 0.21$.

RESULTS

Table 1 which follows shows the calculated means and standard deviations of the variables.

Table 1

Means and Standard Deviations of the variables

Variable[a]	Mean	Standard Deviation
X_1 (S151)	2.55	1.153
X_2 (IQ)	113.25	9.613
X_3 (HSR)	2.33	1.067
X_4 (SAT-M)	468.36	84.518
X_5 (HSMG)	2.47	0.705

[a]See text for identification of variables.

Table 2 which follows shows the inter-correlations between the variables. It should be pointed out that all the correlations with X_3 (high school rank) are negative because that scale is inverse to the other scales. A one in high school rank indicates the top fifth and a five indicates the bottom fifth. If we were to reverse the high school rank scale it would only change the sign of the correlation coefficient.

Table 2

Correlations Between the Variables

Variable[a]		X_1	X_2	X_3	X_4	X_5
X_1	(S151)	----	0.36	-0.42	0.50	0.40
X_2	(IQ)		----	-0.20	0.60	0.18
X_3	(HSR)			----	-0.18	-0.64
X_4	(SAT-M)				----	0.23
X_5	(HSMG)					----

[a]See text for identification of variables
Values exceeding $\pm$ .15 are significant at the .05 level.
Values exceeding $\pm$ .21 are significant at the .01 level.

Tables 3, 4, 5 and 6 which follow show the crossbreaks of each of the independent variables with the dependent variable. Since the dependent variable (S151 grade) was a five step scale the independent variables were also broken into five step scales. The entries in the table are listed as percentages and rounded to the nearest percent.

Table 3

S151 Grades verses I.Q.

S151 Grade	IQ (Percent) 85-95	96-106	107-117	118-128	129-139	Total
0	12	44	44	0	0	100
1	17	8	33	33	9	100
2	6	36	39	19	0	100
3	0	14	58	21	7	100
4	0	11	26	52	11	100
Total Class	4	20	43	27	6	100

Table 4

Crossbreak

S151 Grades verses HSR

S151 Grade	Top Fifth	HSR (Percent) 2	3	4	Bottom Fifth	Total
0	0	11	67	22	0	100
1	8	42	25	17	8	100
2	19	23	29	26	3	100
3	28	33	30	7	2	100
4	48	44	8	0	0	100
Total Class	26	32	27	12	3	100

Table 5

Crossbreak

S151 Grades verses SAT-M

S151 Grade	SAT-M (Percent) 298-378	379-459	460-540	541-621	622-702	Total
0	37	61	0	0	0	100
1	42	33	17	8	0	100
2	13	48	32	7	0	100
3	9	28	40	23	0	100
4	4	7	48	26	15	100
Total Class	14	31	35	17	3	100

Table 6

Crossbreak

S151 Grades verses HSMG

S151 Grade	HSMG (Percent) 0.3-1.1	1.2-1.8	1.9-2.5	2.6-3.3	3.4-4.0	Total
0	11	22	45	11	11	100
1	0	42	25	33	0	100
2	0	32	26	32	10	100
3	2	9	33	42	14	100
4	0	4	19	59	18	100
Total Class	2	18	28	40	12	100

Table 7 which follows records the calculations from the linear step-wise regression analysis. The first column indicates what combination of the variables used (1.235 indicates that the dependent variable X_1 was tested against the independent variables X_2, X_3 and X_5). The second column indicates the Pearson-Product-Moment correlation coefficient between the actual S151 grade and the grade predicted from the model used. The last five columns indicate the coefficients of the line of linear regression. The equation for 1.235 is as follows:

$$\text{Predicted S151 grade} = -1.318 + 0.033\ X_2 - 0.262\ X_3 + 0.309\ X_5$$

Table 7

Correlations and Equations
For the Step-wise Linear Regression

Model	R	Regression Equation				
		Constant	X_2	X_3	X_4	X_5
1.2	.357	-2.303	0.043			
1.3	.419	3.605		-0.453		
1.4	.501	-0.654			0.007	
1.5	.395	0.954				0.646
1.23	.503	-0.397	0.034	-0.391		
1.24	.506	-1.498	0.010		0.006	
1.25	.490	-2.830	0.035			0.558
1.34	.602	0.597		-0.366	0.006	
1.35	.450	2.395		-0.305		0.350
1.45	.578	-1.42			0.006	0.484
1.234	.603	0.208	0.005	-0.362	0.006	
1.235	.524	-1.318	0.033	-0.262		0.309
1.245	.581	-2.048	0.008		0.005	0.479
1.345	.610	-0.056		-0.276	0.006	0.219
1.234	.611	-0.474	0.005	-0.271	0.005	0.220

All correlations are significant at the 0.01 level.

For all models the calculated r value exceeds the critical r value (0.210) at the 0.01 level, hence the null hypothesis is rejected and the alternate hypothesis is accepted. The researcher concludes that there is a positive correlation between the dependent variable and all combinations of the dependent variables.

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

Discussion and Implications

The results in Table 2 on page 11 show that there is a correlation of 0.36 between the grade received in finite mathematics and intelligence. This is consistent with the findings of Astin (1971) who found a similar correlation of 0.35 for men and 0.43 for women.

A correlation of 0.50 exist between finite mathematics grades and the Scholastic Aptitude Test in Mathematics. Chissom and Lanier (1975) found a correlation of 0.39, Goldman and Slaughter found a correlation of 0.25, Larson (1976) found a correlation of 0.22 to 0.53 for eight different studies while Wilson (1973) found a correlation of 0.16. Gussett (1974) in a study of 142 women enrolled in freshman mathematics at Longwood College in Farmville, Virginia found this correlation to be 0.62. While most of the previous studies found correlations below that of 0.50 found in this study, this is probably due to the fact that most of these studies delt with a correlation between all freshman grades and the SAT-M while this study as did Gussett's (1974) deals only with freshman mathematics grades. It is important to note that this variable had the highest single correlation in the study while intelligence quotient had the lowest.

Table 2 shows that there was a correlation of -0.42 between the grade received in finite mathematics and high school rank while there was a correlation of 0.40 between the grade received in finite mathematics and the high school mathematics grades. These two variables will be discussed together because the grades received in all subjects in high school determine the high school rank. The amount of intercorrelation between these two variables is shown on Table 2 by the -0.64. This is the highest correlation in this study. It should be pointed out that all the correlations with high school rank are negative because that scale is inverse to the other scales. A one in high school rank indicates the top fifth while a five indicates the bottom fifth. If we were to reverse the high school rank scale it would only change the algebraic sign of the correlation coefficient.

Astin finds a correlation of 0.50 for men and 0.51 for women between high school grades and freshman grade point average. Chissom and Lanier (1975) find a correlation of 0.46, McDonald and McPherson find a correlation of 0.18, Price and Kim (1976) find a correlation of 0.24, Siegelman finds a correlation of .24 for males and .32 for females, Humphreys finds a correlation of .387 and Larson and Scontrino (1976) find a correlation of between .58 and .72 in eight different years of study. Again, all of the above studies were for correlations between all freshman grades and either high school rank or high school grades.

The crossbreaks, Tables 3, 4, 5 and 6 graphically display the data used in this analysis. As can be seen from Table 3, intelligence quotients are distributed normally about the center group. However, Tables 4 and 6 show that high school rank and high school mathematics grades were skewed towards the top fifths. This is in contrast to Table 5 which shows that the SAT-M scores were skewed towards the bottom fifth's.

Table 7 contains all of the step-wise regression models. The first four lines contain the single independent variable models and replicates the data found in the first line of Table 2. The best single predictor is is variable X_4, SAT-M, high school rank and high school mathematics grades are the next two best predictors and the predictor of least value is the intelligence quotient.

The next six lines of Table 7 include all of the models using two independent variables. As would be expected the combination of the two best single predictors, SAT-M and high school rank, give the best predictive model for two variables. In moving from the one variable to the two variable model there is an improvement in r of .101.

The next four lines of Table 7 include all of the models using three independent variables. Again, as would be expected the three best single predictors combine to form the best predictive model for three variables. The improvement in r between the two variable model and the three variable model is 0.008.

The final line of Table 7 is the full model. This model uses all four independent variables and shows an improvement in r of only 0.001 in moving from the three variable model to the full model. The full model shows a correlation of 0.611 between the predicted grade in finite mathematics and the actual grade received. The prediction formula is:

$$\text{Predicted S151 grade} = -0.474 + 0.005\ \text{IQ} - 0.271\ \text{HSR} + 0.005\ \text{SAT-M} + 0.220\ \text{HSMG}.$$

If one were to substitute the means for the independent variables found in Table 2 into the prediction equation the following results would be obtained.

Table 8

Predicted Mean S151 Grade

Variable	Weight	Mean	Weight x Mean
Constant	-0.474	------	-0.474
IQ	0.005	113.25	0.557
HSR	-0.271	2.33	-0.631
SAT-M	0.005	468.36	2.553
HSMG	0.220	2.47	0.543
Predicted S151 Grade			2.548

The correlation coefficient for the full model was 0.611. Thus $R^2 = 0.373$, indicating that only about thirty-seven percent of the variation in the grade in finite mathematics was explained by this set of four independent variables.

The correlation of 0.611 for the full model was consistent with the findings of other authors. Larson and Scontrino (1976) found a correlation of between 0.60 and 0.73 in eight years of study with high school grades and SAT scores. Astin found correlations of .52 for males and .55 for females in a combination of high school grades and aptitude test. Gussett (1974) found a correlation of 0.63 between freshman mathematics grades and combined SAT scores.

It should be pointed out that the literature indicated that the best single predictor of freshman achievement is the past high school record. This research clearly indicates that for this population the best single predictor was the SAT-Mathematics score. This could be due to the fact that this study was done only on freshman mathematics achievement and not based upon total freshman grade point average.

Recommendations

1) A copy of this study will be given to the mathematics department and the admissions office of the College.

2) That the findings of this study be used by the Admissions Office to improve their techniques in placing freshmen in mathematics courses.

3) That placement in freshmen mathematics courses be determined by SAT-Mathematics scores, high school rank, high school mathematics grades and intelligence quotient in that order.

4) That other departments study predictors of success for their freshman courses. In particular those courses required of all freshmen should be studied.

5) That other factors be studied as possible predictors of success in college. The literature points to the following; sex, age, SAT-Verbal and Total, other achievement and aptitude test and attitudinal scales.

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